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ABSTRACT

One of a series on the visual information transfer problems of the partially sighted, the report contains a detailed description of the double X-Y platform, a mechanical device used in conjunction with a closed circuit television system to permit users to read printed or handwritten materials and to take notes on or copy from the material. Also described are alternative approaches for handling visual information transfer problems and experiments (the results of which were inconclusive) with either single or double X-Y platforms. Appendixes contain instructions for using the double X-Y platform, a description of the platform's construction, and additional experimenter observations and comments. (LH)

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# A DOUBLE X-Y PLATFORM FOR RANDSIGHT-TYPE INSTRUMENTS

PREPARED FOR THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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# PREFACE

This is the third in a series of reports on research being carried on at The Rand Corporation with a grant from the Social and Rehabilitation Service of the U.S. Department of Health, Education, and Welfare to study the information transfer problems of the partially sighted. This report contains a detailed description of a double X-Y Platform, which can be used in conjunction with a closed circuit TV system for the partially sighted and substituted for the single X-Y Platform that has proved to be such a useful and vital part of such systems. The double X-Y Platform permits the partially sighted to read printed and handwritten material, and, with a pen or pencil, to comfortably copy from or take notes on what has been read.

A double X-Y Platform has been used by one of the authors on a day-to-day basis for the past 18 months. His comments and suggestions, regarding its use, as well as those of other users, are also contained in this report.

## SUMMARY

This report describes a mechanical platform called a double X-Y Platform. When this platform replaces a single X-Y Platform as part of a closed circuit TV system for the partially sighted, it permits a user to read printed or handwritten material and to take notes on or copy from that material using a pen or pencil. The platform has two rectangular working surfaces whose motions in the left or right direction (x-direction) are completely coupled, but whose motions toward or away from the user (y-direction) are completely independent of one another. This design feature allows the user to change from reading (writing) to writing (reading) without having to search for the line that he was last writing (reading).

Other techniques for handling this important visual information transfer problem have been explored and are also described in this report. However, they do not appear to be as cost-effective as the double X-Y Platform.

A series of experiments was performed with the cooperation of four partially sighted people who differed in age and ocular pathology. These experiments were an attempt to determine whether copying from unbound and bound materials using a CCTV system equipped with a double X-Y Platform can be expected to be more rapid than copying from similar materials using a CCTV system equipped with a single X-Y Platform, or using neither an X-Y Platform nor a CCTV system. The results of these experiments were not conclusive. However, three of the four subjects reported that they could copy more easily with a CCTV system equipped with a double X-Y Platform than they could using either of the other two techniques.

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## CONTENTS


PREFACE ..... iii

SUMMARY ..... v

ACKNOWLEDGMENTS ..... vii

FIGURES ..... xi

Section

I. INTRODUCTION ..... 1

II. USE OF THE DOUBLE X-Y PLATFORM ..... 3

III. DESCRIPTION OF THE DOUBLE X-Y PLATFORM ..... 7

IV. ALTERNATIVE APPROACHES ..... 12

V. EXPERIMENTS WITH DOUBLE AND SINGLE X-Y PLATFORMS .. 16

Appendix

A. INSTRUCTIONS ON HOW TO USE THE DOUBLE X-Y PLATFORM ..... 25

B. DESCRIPTION OF THE CONSTRUCTION OF THE DOUBLE X-Y PLATFORM ..... 30

C. EXPERIMENTER OBSERVATIONS AND COMMENTS ..... 40

REFERENCES ..... 43

## FIGURES


1. Reading with the aid of a double X-Y Platform. The material to be read has been placed on the left-hand platform and is being viewed by the TV camera ..... 4
2. Writing with the aid of a double X-Y Platform. The writing pad has been placed on the right-hand platform and brought under the camera for viewing ..... 5
3. Double X-Y Platform: Carriage frame extended to the right, reading platform extended to the rear, and writing platform extended forward ..... 8
4. Double X-Y Platform: Carriage frame closed, reading platform extended to the rear, and writing platform extended forward ..... 9
5. Reading with the aid of the double X-Y Platform. The reading platform is to the right of the writing platform ..... 26
6. Writing with the aid of the double X-Y Platform. The reading platform is to the right of the writing platform ..... 27
7. Closed double X-Y Platform ..... 31
8. Detail of one of the ten ball-bearing rollers mounted along the edge of the base plate ..... 32
9. Bottom view of a double X-Y Platform ..... 33
10. Roller and channel detail of the double X-Y Platform ..... 34
11. Detail of the carriage frame assembly and platform channels of the double X-Y Platform ..... 36
12. Bottom view of the double X-Y Platform showing rubber stop blocks for Y-axis motions ..... 37

# I. INTRODUCTION

Those who are familiar with the partially sighted may already be aware of how difficult it is for members of that population to read printed and handwritten material *and* to copy from or take notes with a pen or pencil on what has been read. Most of these people are unable to read ordinary printed or handwritten material without the aid of special eyeglasses, a hand-held or stand-mounted magnifier, or a closed circuit TV system. Also, most partially sighted people cannot both write with a pen or pencil and see what they are writing without the help of special eyeglasses or a closed circuit TV system.[1] A few of these people are able to read ordinary printed or handwritten material, and to both write with a pen or pencil and see what they are writing without an optical or electro-optical aid. However, we doubt whether there are many partially sighted people who can read printed or handwritten material and *comfortably* take notes on or copy from that material using a pen or pencil. Even those who are able to read printed or handwritten material and to write with a pen or pencil without an optical or electro-optical aid are obliged to bring such material close to their eyes. One way they might do this—a procedure Genensky used before a closed circuit TV system was available—can be briefly outlined as follows:

1. Pick up the reading material and bring it close enough to your eyes to be read.
2. Locate the place where you are to begin reading.
3. Read until you feel that (a) you should take notes on, or you should copy material from, what you have read, or (b) until you have completed the reading and writing process.
4. If 3(a) is the case, set the reading material aside.
5. Move the writing paper into position and bend over it until you can clearly see its contents.
6. Determine where you are to begin writing.
7. Take notes on or copy from what you have read until (a) you are to begin reading again or (b) until you have completed the reading and writing process.
8. If 7(a) is the case, set the writing paper aside and return to step 1.

Note that until the design and fabrication of closed circuit TV systems, the partially sighted were obliged to either move reading material and writing paper themselves into and out of their field of view or make whole body motions from one to the other. Unlike the normally sighted, most partially sighted people are unable to shift from reading to writing or vice versa by merely moving their eyes or their heads. Hence, for them, since reading materials were in one location and writing paper in a *distinctly separate* location, they were obliged to move alternately from one of these locations to the other.

Present-day closed circuit TV systems that are equipped with a single X-Y Platform permit the partially sighted, while seated erect and comfortably, to take

[1] E. B. Mehr, A. B. Frost, and L. E. Apple working with 30 partially sighted veterans have found that all the veterans could write neatly and clearly with a closed circuit TV system, but that some were not able to do this with the best available optical aids (i.e., special eyeglasses). See Ref. 1 for more details.

notes on, or copy from, what they have read. Further, these systems allow them to view an enlarged and in-focus image with either ordinary or reversed contrast. However, even with such a system, the partially sighted are obliged alternately to bring into and remove from the TV camera's field of view one type of material (reading or writing) and then the other. This is not easy to do, because it is difficult to determine quickly where to begin reading again, and, for some partially sighted people, where to begin writing again.[2]

This follows from the fact that the partially sighted are not able to scan printed or handwritten material as the sighted can, and from the fact that they can see only a limited portion of a line of print or handwriting at one time—and frequently only a few letters at one time. Genensky, for example, can see only 12 to 15 typewritten letters at one time.

[2] The situation is usually less critical with respect to writing than to reading, because most of the partially sighted can determine where they left off writing by placing the writing paper on the upper face of the X-Y Platform and then maneuvering that surface until the TV camera is viewing handwriting in juxtaposition with an expanse of blank space below and to the right.

## II. USE OF THE DOUBLE X-Y PLATFORM

We have found a very simple and effective way of helping the partially sighted user of a closed circuit TV system to cope with the problem of determining quickly where to begin reading and writing again when involved in any activity that requires shifting attention back and forth between two sets of materials, and, in particular, when involved in the process of reading and taking handwritten or printed notes on or copying from what has been read. We have constructed a double X-Y Platform, that is, a platform that has two working surfaces whose x-motions (left and right) are completely coupled, but whose y-motions (forward and backward) *are completely independent of one another.* When such a platform is placed on a desk or table below a down-pointing TV camera, and centered and aligned with respect to this camera so that an erect image of the platform's working surfaces is seen on the TV monitor screen, it is possible to handle the reading and note-taking or copying problem as follows. (See Figs. 1 and 2.)

Place and align the reading material on one working surface and place and align the writing material on the other surface. Maneuver the working surface that supports the reading material (hereafter referred to as the reading platform) until the area where reading is to begin is seen on the monitor screen at a place that is convenient. Reading is then carried out by moving the reading platform from right to left to view a line and toward the rear of the double X-Y Platform to advance to the next line. When it is time to take notes on or copy what has been read, the user pulls the reading platform toward the left until the image of the left margin of the writing material is at a convenient location on the monitor screen. The working surface that supports this material (hereafter to be called the writing platform) is maneuvered, either forward or backward, until the image of the line on which writing is to begin is conveniently located on the monitor screen. The user begins writing with his writing hand, simultaneously moving the writing platform to the left with the nonwriting hand at a rate that causes the image of the tip of the writing instrument to remain within a small and convenient area of the monitor screen. He pushes the writing platform toward the rear to advance to the next line. When he has completed writing and wishes to begin reading again, he pushes the reading or writing platform to the right until the line and word where he had stopped reading reappear on the monitor screen at the same height on that screen that they occupied previously. *This will occur if the user has not moved the reading material on the reading platform and if he has not moved the platform in the y direction since last leaving the reading material to take notes on or copy what he has read.* Reading is then carried out as described above, and when it is again time to take notes on or copy what has been read, the user pulls to the left either the reading or writing platform until the line and word where he had stopped writing reappear on the monitor screen at the same height on that screen that they had previously occupied. *This will occur if the user has not moved the writing material on the writing platform and if he has not moved the platform in the y-direction since last leaving writing to return to reading.*

Thus we see that when a period of writing (reading) is completed and the user wishes to return to reading (writing), the double X-Y Platform will "remember" the

line on which he was last reading (writing) and will cause that line to reappear at the same height on the monitor screen it previously occupied, provided the admonitions, as given above in italics, are adhered to. This feature of the double X-Y Platform eliminates the time-consuming and frustrating search that takes place when a partially sighted person tries to locate the line on which he last left off reading or writing in the course of reading and trying to take notes on, or to copy what has been read, *without the aid of a closed circuit TV system equipped with such a platform.*

Appendix A contains a set of detailed instructions on how to use a double X-Y Platform to read and take notes on or copy what has been read, as well as how to carry out the single operations of reading or writing.

## III. DESCRIPTION OF THE DOUBLE X-Y PLATFORM

The double X-Y Platform consists primarily of four components:

1. A base structure that supports the platform and that rests on twelve rubber feet that are attached to the front and back of the base.
2. A carriage frame that moves on ten ball-bearing rollers that are attached to the two longest vertical sides of the base structure. A rubber stop block, attached to the under face of the carriage frame and running in a slot cut in the base plate, permits the carriage frame to move left or right (i.e., in the x-direction) 10.25 in. to either side of its centered position (i.e., the one in which the carriage frame is closed with respect to the base structure).
3. A reading platform whose upper face is 14.5 in. in the x-direction and 14 in. in the y-direction. This platform usually supports reading material, but if the user prefers it can be used to support writing material. It moves toward or away from the user (i.e., in the y-direction) on ten ball-bearing rollers which are attached to two vertical sides of the carriage frame, traveling a distance of 6 in. on either side of the position in which the reading platform is closed with respect to the carriage frame.
4. A writing platform whose upper face is 9.5 in. in the x-direction and 14 in. in the y-direction. This platform usually is used to support writing material, but like the reading platform it can be used to support either reading or writing materials. Again, like the reading platform, the writing platform moves toward or away from the user on ten ball-bearing rollers which are attached to two other vertical sides of the carriage frame, traveling a distance of 6 in. on either side of the closed position.

The overall dimensions of the double X-Y Platform when fully closed are 24 by 14 by 1.5 in. and, from what has been said above concerning the distance through which the carriage frame and reading and writing platforms can travel, it is seen that the double X-Y Platform requires an area 44.5 by 26 in. free of clutter to operate unhindered. Although this area may appear to be rather large, it has not precluded the use of such a platform on a regular-size office desk. Genensky has used one on such a desk on a daily basis for about 18 months without any difficulty (see Figs. 1 and 2).

Figure 3 illustrates the double X-Y Platform when the carriage frame is fully extended in one direction and the reading and writing platforms are fully extended in directions opposite to one another. In Fig. 4 the carriage frame is closed with respect to the base structure.

The motions of the reading and writing platforms in the x-direction are fully coupled and completely governed by the motion of the carriage frame. However, the motions of these platforms in the y-direction are independent of one another and independent of the motion of the carriage frame.

C-shaped roller channels run along the longest dimension of the carriage frame, and similar channels run along the 14 in. dimension of both the reading and writing platforms. The c-shaped channels on the carriage frame enclose the ball-bearing rollers attached to the base structure and constrain the carriage frame from moving in the y-direction. Similarly, the c-shaped channels on the reading and writing

platforms enclose the ball-bearing rollers attached to the portion of the carriage frame with which each of the platforms is associated and constrain these platforms from moving in the x-direction relative to the carriage frame. Usually, the rollers ride on the under face of the moving structure they support. If the structure (i.e., the carriage frame or the reading or writing platforms) lifts up from the rollers, the latter begin to roll on the upper faces of the bottom of the roller channel. The bottom of each of these c-shaped channels consists of a Delrin capping bar. Delrin was selected because it is a hard plastic material that produces very little friction and no galling when in contact with various metals. Before installing Delrin capping bars, we used both brass and aluminum capping bars and found that galling occurred where they were in contact with the sides of the guide bars.

The guiding mechanism used in conjunction with the motions of the double X-Y Platform's carriage frame and reading and writing platforms described above differs from the one we used in the construction of our single X-Y Platforms. The x- and y-motions of the reading and writing platform of our single X-Y Platforms is carried out via two pairs of aluminum drawer slides placed at right angles to one another (see Ref. 2). The use of drawer slides was rejected in favor of the roller and channel approach, because the latter (1) provided better support of the carriage frame throughout its motion, (2) allowed the use of a smaller base structure, and (3) permitted a reduction in overall platform height. The better support of the carriage frame and the reduction in platform height were considered important, because we were concerned that the platform might otherwise become unstable when the carriage frame was fully extended.

Mechanisms are provided for creating friction in the motions of the reading and of the writing platforms. The friction contributed by these mechanisms cannot be adjusted without partially disassembling the overall platform. However, a simple redesign that allows external control of the friction should be possible.

As pointed out earlier, the movement of the carriage frame in the x-direction is limited by the length of the slot in the base structure within which the stop block, attached to the under face of the carriage frame, is constrained to move. Similarly, the motion in the y-direction of both the reading and writing platforms is limited by a pair of stop blocks, which are attached to the under face of each platform, and by a crossbar of the carriage frame, which runs in the x-direction, is centrally located, and lies below each of the platforms.

Stripes and a circle are painted on the upper face of the reading and writing platforms. These markings are used to align and center the double X-Y Platform below the TV camera, and to align reading and writing materials on the reading and writing platforms. The colors chosen for these lines and for the surfaces on which they are drawn have gray values that are easily distinguishable from each other on a black and white TV monitor, but do not tend to degrade the quality of the image of reading and writing materials when these materials and colors appear on the monitor screen at the same time.

The double X-Y Platform when closed is completely symmetric with respect to its longest dimension. Thus, the platform can be used equally well with its reading platform located to the right or to the left of its writing platform. This permits both left- and right-handed persons to use the platform with equal ease.

Finally, we tried to design the double X-Y Platform so as to minimize the possibility of a user hurting himself. For example, we removed the sharp edges from all exposed metallic members and rounded others that appeared hazardous. Care, however, must be taken to instruct a new user, for example,

1. To avoid placing his fingers between the ball-bearing rollers and the c-

shaped channels that enclose these bearings when the carriage frame assembly and the reading and writing platforms are in motion.

2. To keep his fingers out of the slot that accommodates the stop block attached to the under face of the carriage frame assembly.
3. To avoid placing his fingers in both the larger and the smaller rectangles of the carriage frame assembly to prevent having them jammed between these frames and the reading and writing platforms, respectively.
4. To avoid placing the double X-Y Platform on a raised surface to which it is not screwed or bolted and where it might tip over when it is extended in one or more directions.

A more detailed description of the construction of a double X-Y Platform is given in App. B.

# IV. ALTERNATIVE APPROACHES

A series of twelve experiments, involving various experimental mock-ups, were performed, ten of which involved alternative approaches to the solution, described in previous sections of this report, of the problem of reading printed or handwritten material and copying that material using a pen or pencil. The other two experiments (experiments 3 and 4 below) involved the alternative described previously. The object of these experiments was to determine whether any of the examined approaches to solving the copying problem would prove distinctly superior to the other approaches. The measured criterion used to judge the relative merits of the various approaches was the copying rate achieved by the experimental subject in each experiment. The copying rate is defined as the average number of words per minute copied during the course of an experiment.

Genensky, the experimental subject, was asked to sit before each of the experimental mock-ups, and to use them to copy for ten-minute spans from double-spaced typewritten copies of stories that appear in graded volumes at the sixth level published by the *Reader's Digest*. The typewritten material was produced on an IBM Selectric typewriter, which types 10 characters to the inch and which was equipped with a 12-pitch letter Gothic element. A different typewritten page was used for each experiment and each trial of each experiment; none of this material had been read by Genensky before these experiments.

The test bed for the experiments consisted of a specially built heavy-duty metal table.[1] Two vertical columns were attached to either the back or sides of the table and could be easily moved to a new position if required. Each of these columns provided support to a horizontal member, which could be rotated about its support column and could be raised or lowered with respect to the column. Each of the horizontal members was equipped with a bracket at its free end, which supported a down-pointing TV camera and permitted the camera and its zoom lens to be rotated about the optical axis of the lens. A light source was provided for the camera and was attached to the horizontal member supporting the camera. In some of the experiments, two cameras were required to permit the viewing of both reading and writing material independently of each other. Information gathered by one or both of the TV cameras was presented on a 9 in. TV monitor, which was supported at the end of a horizontal arm, which in turn was attached to a vertical column that could be raised or lowered in a columnar pedestal. The horizontal arm could be rotated about its columnar support, and the monitor could be rotated about an axis perpendicular to its top and bottom faces, passing approximately through its center of gravity, and about another axis perpendicular to its vertical side faces, again passing approximately through its center of gravity. This allowed the monitor to be placed in positions that were convenient for the user.

For *experiment 1*, we placed a single X-Y Platform on the top of a table and centered it below the TV camera on the right, as viewed from the front of the table. The user rotated the platform to permit him to write comfortably. After aligning the typewritten material on the X-Y Platform, the user rotated the camera and its zoom lens about the optical axis of the lens until he saw an erect image of the material on the TV monitor. He then adjusted the magnification provided by the zoom lens

[1] Designed and built with funds received from the Social and Rehabilitation Service under a prior grant, 14-P-55846/9.

to produce an easily readable image of the material. After some practice, he then read and copied the material for a period of ten minutes. It should be noted that the same lens magnification was used for reading and for writing and that both of these operations took place on the same single X-Y Platform.

*Experiment 2* was exactly the same as experiment 1 except that the single X-Y Platform was centered below the TV camera on the left, as viewed from the front of the supporting table.

For *experiment 3*, we placed a double X-Y Platform on top of the table and centered it below one of the TV cameras. It was rotated so that its larger or reading platform was on the left (as viewed from the front of the table) and located to permit the user to write comfortably. The user then adjusted the camera and its zoom lens to produce an easily readable image of the graded typewritten material. After practice, he then read and copied the material for a period of ten minutes. In this experiment, the reading material was aligned on the larger platform and the writing material on the smaller, and, as in experiments 1 and 2, the same magnification was used for both reading and writing.

*Experiment 4* was similar to experiment 3, differing only in one respect, namely, that the larger of the platforms of the double X-Y Platform was on the right rather than on the left, and hence the reading material was on the right and the writing material was on the left.

As pointed out above, in experiments 1, 2, 3, and 4 the user adjusted the magnification of the zoom lens to provide an easily readable image of the graded typewritten material. He did *not* change the magnification during the cycle of reading and copying. This meant that the image of the writing material tended to be larger than that preferred by the user, but not so large that he could not or would not cope with it, or that it otherwise appeared to adversely affect his writing speed.

For *experiment 5*, we placed two single X-Y Platforms on the table, centering each below the TV cameras. The user rotated the platform on the left to permit him to read comfortably, and the one on the right to permit him to write comfortably. He then rotated each camera, together with its zoom lens, about the optical axis of the lens until he saw an erect image on the TV monitor. In this experiment, we used a special effects generator to produce a horizontal split image—the top of which showed a portion of the reading material and the bottom a portion of the writing material. The user adjusted the magnification provided by each of the zoom lenses to produce an easily discernible image of what the lens viewed. Therefore, in this experiment, unlike experiments 1, 2, 3, and 4, the magnification of the reading material could be chosen independently of that chosen for the writing material without changing the magnification of the zoom lens once the experiment was in progress, that is, once the cycle of reading and copying had begun. After practice, the user carried out the cycle of reading and copying for a period of ten minutes.

*Experiment 6* was almost a repeat of experiment 5 except that the reading material was placed on the right X-Y Platform rather than on the left one.

*Experiment 7* was very much like experiment 5 except that rather than a split image it involved the use of a foot-operated control, which allowed the user to switch alternately from viewing a whole screen image of a portion of the reading material to viewing a whole screen image of a portion of the writing material.

*Experiment 8* was similar to experiment 7 except that the reading material was placed on the right X-Y Platform and writing material on the left.

In *experiment 9*, we placed the double X-Y Platform on top of the table with the larger or reading platform on the left. It was then positioned and rotated to be conveniently located for both reading and writing. One TV camera was located to view the center of the larger platform, and the other TV camera was positioned to

view the center of the smaller or writing platform when the double X-Y Platform was closed in both the x- and y-directions. Each camera, together with its zoom lens, was then rotated about the optical axis of the lens until an erect image of what the camera was viewing was seen on the monitor screen. As in experiments 5 and 6, we used a special effects generator to produce a horizontally split image, the top of which showed a portion of the reading material and the bottom a portion of the writing material. The user adjusted the magnification provided by each of the zoom lenses to produce an easily discernible image of what the lens viewed. Thus, in this experiment, as in experiments 5 through 8, the magnification of the reading material could be chosen independently of that chosen for the writing material without changing the magnification setting on a zoom lens once the experiment was in progress, that is, once the cycle of reading and copying had begun. Here again, after practice, the user carried out the cycle of reading and copying for a period of ten minutes.

It is interesting to note that in this experiment and in experiment 10, persons with normal visual acuity found it very unpleasant to view the TV monitor when the magnification selected for viewing reading material was significantly different from that chosen for viewing the writing material *and* when the double X-Y Platform was being maneuvered in the course of an experiment. These observers were bothered by the fact that as the platform moved in the x-direction the image of the reading material appeared to advance at a different rate than that of the writing material. They reported that this difference in apparent velocity made them feel "dizzy" or "seasick." Genensky was not disturbed by this phenomenon and was able to carry out both experiments 9 and 10 with no ill effects. This is not surprising, however, when it is noted that he is acutely myopic. During these experiments his functioning eye was within a couple of inches of the 9 in. monitor screen, and hence he was rarely visually aware of the writing material when he was viewing the reading material and vice versa.

*Experiment 10* was almost the same as experiment 9 except that the double X-Y Platform was rotated through 180 deg, and hence the reading material was on the right and the writing material on the left.

*Experiment 11* was much like experiment 9 except that rather than a split image it involved the use of a foot-operated control, which allowed the user to switch alternately from viewing a full screen image of a portion of the reading material to viewing a full screen image of the writing material.

*Experiment 12* was similar to experiment 11 except that the double X-Y Platform was rotated through 180 deg, and hence the reading material was on the right and the writing material on the left.

An examination of the results given in Table 1 indicates that the copying rates achieved by the experimental subject showed little variation from experiment to experiment. Hence, based on this criterion, none of the experimental mock-ups would appear to be superior to the others. Therefore, the choice among the alternative approaches to the copying problem was derived by different criteria, namely, how they would affect the design and overall cost of current CCTV systems. Based on these criteria, the substitution of a double X-Y Platform for a single X-Y Platform in the construction of a CCTV system is less complex and far less costly than providing split or sequential viewing, which might involve two cameras and lenses, or at best a new and sophisticated optical system.

The justification for choosing to substitute a double X-Y Platform for a single X-Y Platform, even though this choice requires an increase in overall instrument complexity and cost, is based on the observation of our staff, in the course of these experiments as well as in those discussed in the next section and in App. C, that

Table 1

COPYING RATES ATTAINED BY GENENSKY USING ALTERNATIVE EXPERIMENTAL DESIGNS

| Experiment | Copying Rate (wpm) | Experiment | Copying Rate (wpm) |
|---|---|---|---|
| 1 | 15.4 | 7 | 15.4 |
| 2 | 15.1 | 8 | 14.2 |
| 3 | 16.0 | 9 | 16.4 |
| 4 | 14.6 | 10 | 14.7 |
| 5 | 16.9 | 11 | 15.2 |
| 6 | 16.7 | 12 | 15.2 |

copying with the help of a double X-Y Platform involves less manipulation of reading and writing materials and less frustration and anxiety on the part of the partially sighted user. In addition, Genensky's 18-month experience in using a double X-Y Platform in conjunction with the CCTV system installed in his office also supports our belief that a double X-Y Platform is preferable to a single X-Y Platform, especially when the user's daily work involves considerable copying and note-taking.

# V. EXPERIMENTS WITH DOUBLE AND SINGLE X-Y PLATFORMS

A sequence of experiments was performed with the cooperation of four partially sighted subjects, who were willing and able to contribute the large amount of time needed to carry out these experiments. The experiments were aimed at determining how well the subjects were able to use a closed circuit TV system equipped with either a single or a double X-Y Platform to copy printed material.

The subjects copied the material from double-spaced typewritten pages and from books onto an 8.5 by 11 in. pad of dark blue lined white paper, with 0.375 in. line spacing. The stories on the typewritten pages were taken from the *Reader's Digest* graded readers at the sixth level and were typed in the same way as the material used in the previously described experiments. The type style and spacing of the copy were selected for clarity and readability and to avoid problems associated with letter crowding or decorative serifs. The passages copied from books were taken from *Concepts in Science* (Teacher's Edition) by P. F. Brandwein, E. K. Cooper, P. E. Blackwood, and E. B. Hane (Harcourt, Brace and World, Inc., 1966) and from *A Manual for Remedial Reading* by E. W. Dolch (Garrard Press, 1957). The first book is 7.75 in. wide, 9.25 in. deep, and 1.375 in. thick when closed; 16.375 in. wide and 9.25 in. deep when open; and 376 pages long. The second book is 5.5 in. wide, 8.25 in. deep, and 1.5 in. thick when closed; 12 in. wide and 8.25 in. deep when open; and 464 pages long. In each trial of each experiment in which these text sources were used, the subject was assigned a different passage to read or copy from. However, in any one experiment all the subjects used the same material. Further, throughout the sequence of experiments, each subject was permitted to read and write wearing corrective lenses if he had such lenses and chose to use them.

In the first three experiments *(experiments 1, 2,* and *3),* the subject was asked to carry out one or more tasks without the aid of a closed circuit TV system and without the help of either a single or a double X-Y Platform. In *experiment 1,* he was asked to read aloud from a typewritten copy of a story taken from one of the *Reader's Digest* graded readers. In *experiment 2* he was asked to write, on a pad of lined paper, a connected set of thoughts, which can be loosely referred to as a story based on ideas generated in his own mind. He was also asked to write continuously and not to spend time pondering over what to write next. On completing this task, the subject was requested to read back aloud what he had written. In *experiment 3* he was given another typewritten copy of a *Reader's Digest* story and was asked to copy it onto a pad of paper. When finished, he was asked to read back aloud what he had written.

In the next two experiments *(experiments 4* and *5),* the subject used a closed circuit TV system equipped with a single X-Y Platform. In some cases, these experiments were repeated using a double X-Y Platform rather than a single X-Y Platform to determine whether this change would have any appreciable effect on the subject's reading or writing speed—no significant difference in the resulting speeds was detected. In *experiment 4,* the subject was asked to repeat the task assigned to him in experiment 1, and in *experiment 5* he was asked to repeat the tasks given to him in experiment 2. The reading speed obtained from experiment 4 can be looked upon as a rough approximation of the subject's habitual reading speed when using a closed circuit TV system equipped with an X-Y Platform, and the writing speed obtained from experiment 5 can be considered a rough approximation of his habitual writing speed with the system.

In the next set of three experiments *(experiments 6, 7,* and *8),* the subject was asked to use a closed circuit TV system equipped with a single X-Y Platform to copy several kinds of printed material, and then to read back aloud what he had written. In *experiment 6,* he copied from a typewritten copy of a *Reader's Digest* story, in *experiment 7* he copied from *Concepts in Science,* and in *experiment 8* from *A Manual for Remedial Reading.* The selections to be copied from the two books were chosen from the latter part of each of these texts and spanned at least two adjacent pages. This was done to determine how the subject would cope with having to copy a passage that lay at distances from the TV camera that differed by more than an inch. At low magnifications, the clarity of the image of the print was about the same on either page being viewed, but at high magnifications, the clarity of one page was distinctly better than that of the other if the focus ring on the zoom lens was not adjusted to account for the change in page-to-lens distance.

The final set of three experiments, *experiments 9, 10,* and *11,* were the same as experiments 6, 7, and 8, respectively, except that a double X-Y Platform was substituted for the single X-Y Platform and, of course, a different *Reader's Digest* story and different passages from *Concepts in Science* and *A Manual for Remedial Reading* were designed to be copied in each experiment.

These experiments were carried out to determine whether the experimental subjects could copy from unbound and bound material using a CCTV system equipped with a double X-Y Platform more rapidly than they could without the aid of such a system, or with the aid of such a system equipped with a single X-Y Platform. The measured criterion was the copying rate; however, it turned out that nonmeasured criteria, such as ease of operation and subject fatigue and anxiety, played a significant role in these experiments. This did not become evident to us until after these experiments were completed.

There were four partially sighted subjects in the experiments—three men and a woman, ranging in age from 17 to 46 and with varying degrees of visual disorders. Their experience with a CCTV system ranged from none to extensive. Some of the subjects' individual characteristics are given below:

**Subject A** is a 47-year-old male applied mathematician. He has had corneal scars since shortly after birth. As a result of glaucoma, partial irodectomies were performed on both of his eyes when he was four months old. His distant visual acuity is nil in his left eye and 20/750[1] in his right eye. He is able to read the 20/20 line on a reading card at about one inch from his right eye. He does not use conventional eyeglasses, but he does use binoculars for a variety of purposes and closed circuit TV systems at work and at home to carry out nearly all of his reading and writing. He is very myopic, and, to the best of our knowledge, his right visual field is of normal extent. He is able to maneuver safely in an unfamiliar environment without the aid of a sighted person, a guide dog, or a cane. He is right-handed and right-eye dominant.

Subject A has used a closed circuit TV system at work for the past eight years and another one at home for the past two years. Further, he was the only subject who had had extensive experience using a double X-Y Platform as well as a single X-Y Platform before participating in these experiments.

[1] A person's visual acuity is said to be "m/n," where m and n are positive integers, if at m feet the smallest symbols he can identify on an eye chart are the smallest symbols that a person with normal sight can identify on that chart at a distance of n feet. Thus, for example, if at 20 feet the smallest symbols he can identify on the chart are the smallest symbols a person with normal sight can identify on that chart at 750 feet, his visual acuity is said to be 20/750.

In experiments 2, 3, and 5 through 11, subject A wrote with a fountain pen and always printed. His handwriting was clearly legible to himself and to the experimenter. In experiments 4 through 11, he always used a 9 in. TV monitor.

**Subject B** is a 43-year old male historian. He has macular scars in both eyes resulting from attacks of histoplasmosis in 1968 and 1972. His distant visual acuity with correction is 20/200 in the left eye and 20/160 in the right eye. He is able to read the 20/100 line on a reading card at about four inches with his right eye and the 20/25 line at about three inches with the same eye. He uses corrective lenses for distance viewing but removes them when trying to read at distances of four inches or less. He has recently begun using binoculars for a variety of purposes and has acquired a closed circuit TV system to assist him with his reading and writing. Although he has central scotomas, his peripheral vision is good enough to permit him to maneuver safely in an unfamiliar environment without the help of a sighted person, a guide dog, or a cane. He is right-handed and right-eye dominant.

Subject B has used one of our laboratory closed circuit TV systems for about eight months, and, as pointed out above, has recently purchased a commercially available system for use at home.

In experiments 2, 3, and 5 through 11, subject B wrote with a ball point pen. In experiments 6, 7, and 11, he printed, and his handwriting was legible to himself and to the experimenter. In experiments 2, 3, 5, and 8 through 10, he wrote using a personal shorthand system, and the results of that writing were only readable to himself. In experiments 4 through 11, he always used a 17 in. TV monitor.

**Subject C** is a 27-year-old male student. He has had retrolental fibroplasia since birth. His distant visual acuity is 20/240 in his right eye and 20/200 in his left eye with corrective lenses. He is able to read, without the help of corrective lenses, the 20/60 line on a reading card with his right eye at about two inches and the 20/25 line with his left eye at a distance of about two and a half inches. He is very myopic, has some degree of strabismus, and has scotomas that are the result of a retinoschesis. He wears a conventional pair of glasses for distant viewing, but uses no other visual aid. He is able to maneuver safely in an unfamiliar environment without the aid of a sighted person, a guide dog, or a cane. He is right-handed and left-eye dominant.

Subject C had never used a closed circuit TV system before these experiments. He neither owns such a system, nor does he appear to have any current interest in using or owning one.

In experiments 2, 3, and 5 through 11, subject C wrote with a ball point pen and always printed. His handwriting was legible to himself and to the experimenter. In experiments 4 through 11, he used a 9 in. TV monitor.

**Subject D** is a 17-year-old female student. She has had retrolental fibroplasia since birth. Her distant visual acuity is 20/120 in her right eye and 20/1200 in her left eye. She is able to read the 20/20 line on a reading card with her right eye at about one inch. She does not wear corrective lenses, but over the years has acquired an assortment of handheld magnifiers. Recently she purchased

binoculars to assist her in coping with a variety of visual problems. She has a closed circuit TV system of her own, which she uses in school and at home. She takes the system to her classes on a small wheeled stand. Although her visual field is somewhat restricted, she is able to maneuver safely in an unfamiliar environment without the aid of a sighted person, a guide dog, or a cane. She is right-handed and right-eye dominant.

Subject D was first introduced to a closed circuit TV system in our laboratory a little more than a year ago, and, as pointed out above, has purchased a system that she uses at home and in school.

In experiments 2, 3, and 5 through 11, subject D used a ball point pen, and her handwriting was legible to herself and to the experimenter. In experiments 2, 3, and 11, she printed, and in experiments 5 through 10 she used cursive writing. In experiments 4 through 11, she used a 9 in. TV monitor except during one run of experiment 7 when she used a 17 in. monitor.

Table 2 contains a summary of some of the more important parameters entering into the 11 experiments and of the experimental results. *Column 1* gives the code letter of the subject for whom the parameters and results are reported in adjacent rows and columns; *column 2* contains the number of the experiment; and *column 3* gives the working distance in inches, that is, the distance between the subject's eyes and the face of the TV monitor. In some cases, a range of working distances is given, because in the course of the experiment(s) reported on in the corresponding row of the table, the subject varied the distance between himself and the monitor. *Column 4* contains the linear magnification of the image displayed on the monitor screen. *Column 5* indicates the polarity of the image on the monitor screen—positive (+) if it had a normal gray scale, and negative (-) if it had a reversed gray scale. *Column 6* gives the number of words read, written, or copied; and *column 7* contains the time in minutes and seconds that it took to read, write, or copy these words. *Column 8* gives the reading rate in words per minute (wpm) measured in experiments 1 and 4; *column 9* contains the writing rate in wpm measured in experiments 2 and 5; and *column 10* gives the copying rate in wpm measured in experiments 3 and 6 through 11. Note that the entries given in columns 6 through 10 do not include data collected during the read-back portions of experiments 2, 3, and 6 through 11. *Column 11* gives the time in minutes and seconds that it took to read back aloud the material written or copied in experiments 2, 3, and 5 through 11; and *column 12* contains the rate in wpm at which read-back occurred.

The data in Table 2 describing how copying rates varied as a function of the copying technique and as a function of the experimental participant are, on balance, inconclusive. This becomes clearer from Table 3, which assembles the copying rates for the four experimental participants and for experiments 3 and 6 through 11. The data from experiments 3, 6, and 9 are directly comparable and hence have been grouped together. The same is true of experiments 7 and 10 and 8 and 11. Experiments 3, 6, and 9 involved copying from typewritten material under three different conditions. Here only subject A showed an improvement in copying rate through the use of a CCTV system, and this improvement occurred, surprisingly, when a single X-Y Platform was used. Comparing the results of experiments 7 and 8 with those of 10 and 11, we see that the use of double X-Y Platform resulted in a higher copying rate than the use of a single X-Y Platform in five out of eight cases, but here we have no baseline data on the copying rate from bound volumes when a CCTV system is not used. Similarly, all the copying rates from bound volumes (experiments 7, 8, 10, and 11) were lower than the copying rates from typewritten pages without the use

Table 2

SUMMARY OF EXPERIMENTAL PARAMETERS AND MEASUREMENTS FOR EXPERIMENTS 1 THROUGH 11

| (1) Subject | (2) Experiment Number | (3) Working Distance (in in.) | (4) Linear Magnification | (5) Polarity | (6) Number of Words | (7) Time (in min and sec) | (8) Reading Rate (wpm) | (9) Writing Rate (wpm) | (10) Copying Rate (wpm) | (11) Readback Time (in min and sec) | (12) Readback Rate (wpm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1 | 1.5-1 | 1 | | 130 | 1-0 | 130.0 | | | | |
| | 2 | 1 | 1 | | 434 | 19-55 | | 21.8 | | 4-5 | 160.4 |
| | 3 | 1 | 1 | | 426 | 30-11 | | | 14.1 | 3-5 | 108.7 |
| | 4[a] | 2.5 | 4.375 | - | 371 | 2-58 | 124.9 | | | | |
| | 5 | 1.5 | 2.75 | - | 202 | 6-15 | | 32.3 | | 2-15 | 89.8 |
| | 6[a] | 1.5 | 2.375 | - | 145 | 9-19 | | | 15.6 | 1-25 | 102.1 |
| | 7[a] | 1.75 | 2.5 | - | 215 | 15-20 | | | 14.0 | 2-24 | 89.6 |
| | 8 | 1.5 | 2.5 | - | 486 | 40-50 | | | 11.9 | 7-20 | 66.3 |
| | 9 | 1.5 | 2.5 | - | 586 | 44-30 | | | 13.2 | 9-5 | 64.5 |
| | 10 | 2.5 | 2.5 | - | 511 | 44-45 | | | 11.4 | 7-32 | 67.9 |
| | 11 | 1.5 | 2.75 | | 497 | 37-20 | | | 13.3 | 6-55 | 71.8 |
| B | 1 | 3.5 | 1 | | 238 | 2-27 | 97.1 | | | | |
| | 2 | 12.5-9 | 1 | | 145 | 6-28 | | 22.4 | | 2-0 | 72.5 |
| | 3 | 6-5 | 1 | | 116 | 5-38 | | | 20.6 | 1-45 | 66.8 |
| | 4[a] | 25.5 | 9.62 | + | 416 | 5-11 | 80.3 | | | | |
| | 5[a] | 25.25 | 9.37 | + | 191 | 5-0 | | 38.2 | | 4-25 | 43.2 |
| | 6 | 20-18 | 8.75 | + | 281 | 19-5 | | | 14.7 | 4-15 | 66.1 |
| | 7 | 23 | 11 | + | 371 | 18-50 | | | 19.7 | 4-57 | 74.9 |
| | 8 | 21-18 | 9 | + | 484 | 35-0 | | | 13.8 | 10-2 | 48.3 |
| | 9 | 25.5 | 8.5 | + | 589 | 55-49 | | | 10.6 | 14-37 | 40.3 |
| | 10 | 19.5 | 10 | + | 504 | 45-0 | | | 11.2 | 11-12 | 45.0 |
| | 11 | 19.5 | 9 | + | 496 | 38-55 | | | 12.9 | 6-13 | 79.7 |

[a]Average of more than one trial.

Table 2--Continued

| (1) Subject | (2) Experiment Number | (3) Working Distance (in in.) | (4) Linear Magnification | (5) Polarity | (6) Number of Words | (7) Time (in min and sec) | (8) Reading Rate (wpm) | (9) Writing Rate (wpm) | (10) Copying Rate (wpm) | (11) Readback Time (in min and sec) | (12) Readback Rate ($w_1$m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C | 1 | 2.5 | 1 | | 234 | 1-30 | 156.0 | | | | |
| | 2 | 2.5 | 1 | | 176 | 8-12 | | 21.5 | | 1-12 | 146.6 |
| | 3 | 2.5 | 1 | | 298 | 15-37 | | | 19.1 | 2-0 | 149.0 |
| | 4[a] | 5.87 | 3.87 | + | 435 | 3-37 | 120.2 | | | | |
| | 5[a] | 4.25 | 3 | (+)(-) | 226 | 12-24 | | 18.2 | | 2-15 | 100.4 |
| | 6 | 6.5 | 2.25 | - | 30 | 2-0 | | | 15.0 | -- | -- |
| | 7 | 4.5 | 3 | + | 237 | 19-15 | | | 12.3 | 3-3 | 77.7 |
| | 8 | 5.5 | 5 | + | 484 | 39-15 | | | 12.3 | 5-45 | 84.2 |
| | 9 | 9 | 5.5 | + | 591 | 51-10 | | | 11.6 | 7-28 | 79.1 |
| | 10 | 9 | 2.75 | + | 504 | 37-40 | | | 13.4 | 5-0 | 100.8 |
| | 11 | 7.5 | 5.5 | + | 499 | 35-38 | | | 14.0 | 6-13 | 80.2 |
| D | 1 | 5 | 1 | | 234 | 1-25 | 164.7 | | | | |
| | 2 | 8 | 1 | | 176 | 11-9 | | 15.8 | | 1-15 | 140.8 |
| | 3 | 5.5-3.5 | 1 | | 340 | 17-26 | | | 19.5 | 2-4 | 164.3 |
| | 4[a] | 11 | 5 1/2 | + | 266 | 3-0 | 83.7 | | | | |
| | 5 | 12 | 5 1/2 | + | 213 | 18-12 | | 11.7 | | 2-12 | 96.8 |
| | 6 | 10.5 | 2 | + | 280 | 25-50 | | | 10.8 | 2-15 | 124.4 |
| | 7[a] | 18.25 | 5.37 | (+)(-) | 328 | 37-8 | | | 8.8 | 3-59 | 82.4 |
| | 8 | 10 | 2 | + | 465 | 46-50 | | | 9.9 | 4-20 | 107.3 |
| | 9 | 10.5 | 3.37 | + | 581 | 61-18 | | | 9.5 | 5-55 | 98.1 |
| | 10 | 9 | 2.5 | + | 494 | 54-10 | | | 9.1 | 5-29 | 90.1 |
| | 11 | 9 | 3.37 | + | 490 | 48-4 | | | 10.2 | 4-53 | 100.4 |

[a]Average of more than one trial.

Table 3

SUMMARY OF COPYING RATES FROM SELECTED EXPERIMENTS

(wpm)

| | Type of Reading Material | | | | | | |
|---|---|---|---|---|---|---|---|
| | Typewritten Copy from *Reader's Digest* | | | Bound Volume, *Concepts in Science* | | Bound Volume, *A Manual for Remedial Reading* | |
| Subject | No Aids (Exp. 3) | CCTV and Single X-Y Platform (Exp. 6) | CCTV and Double X-Y Platform (Exp. 9) | CCTV and Single X-Y Platform (Exp. 7) | CCTV and Double X-Y Platform (Exp. 10) | CCTV and Single X-Y Platform (Exp. 8) | CCTV and Double X-Y Platform (Exp. 11) |
| A | 14.1 | 15.6 | 13.2 | 14.0 | 11.4 | 11.9 | 13.3 |
| B | 20.6 | 14.7 | 10.6 | 19.7 | 11.2 | 13.8 | 12.9 |
| C | 19.1 | 15.0 | 11.6 | 12.3 | 13.4 | 12.3 | 14.0 |
| D | 19.5 | 10.8 | 9.5 | 8.8 | 9.1 | 9.9 | 10.2 |

of a CCTV system (experiment 3). However, the results are mixed when copying rates from bound volumes are compared with copying rates from typewritten pages using the same type of visual aid. Comparing copying rates from bound volumes (experiments 7 and 8) with copying rates from flat pages (experiment 6)—experiments in which a single X-Y Platform was used—the copying rates in the former experiments are found to be less than those that occurred in the latter experiment in seven out of eight cases. Similarly, comparing copying rates from bound volumes (experiments 10 and 11) with copying rates from flat pages (experiment 9)—experiments in which a double X-Y Platform was used—the copying rates in the former experiments are found to be greater than those in the latter experiment in six out of eight cases.

Because only subject A achieved a higher copying rate with a CCTV system equipped with a double or a single X-Y Platform than he did when copying without the aid of a CCTV system and either type of platform, we might be tempted to conclude that copying without the aid of such a system and such platforms is more effective than copying with such aids. However, this probably is not the case, particularly with respect to copying with a CCTV system equipped with a double X-Y Platform, because parameters that are important but that can't be reported as precisely as copying rates enter into this visual information transfer problem. Examples of such parameters are discomfort, anxiety, and frustration—all of which, by the way, were observed (subjectively) by the experimenter and commented on by the subjects themselves. Three of the subjects as well as the experimenter himself found that these effects were lower when using the CCTV system equipped with a double X-Y Platform than when using no CCTV system or one equipped with a single platform. Further, all four subjects looked favorably on the double X-Y Platform and recognized its value to them in situations where copying from or taking notes on printed material was a vital component. However, not all the subjects thought that they would be faced with enough situations that warranted their learning to use a

double X-Y Platform proficiently. In some cases, such comments may be justified, but in others they may reflect an unwillingness to change a modus operandi with which the subject is comfortable for a procedure with which he is unfamiliar but that in the long run may prove to be more helpful to him.

At least one piece of evidence does exist that appears to support our belief that the relative merit of reading and copying with a double X-Y Platform as opposed to a single X-Y Platform should not be judged merely in terms of measured copying rates. This evidence was unexpectedly uncovered by the experimenter when carrying out experiments 6 through 11 with subjects A and B and after similar experiments were carried out with subjects C and D. The experimenter observed that the number of transitions from reading to writing and from writing to reading made by subjects A and B, when reading and copying with the aid of a single X-Y Platform, was about four times as large as the number of such transitions made when they read and copied from comparable material with a double X-Y Platform. The experimenter's concern, for example, with noting reading and writing times, measuring working distances and linear magnifications, and observing subject actions, attitudes, and physical well-being, precluded the possibility of his measuring individual transition times. However, his subjective judgment leads him to conclude that the distribution of the time spent in a single transition is about the same for these subjects whether they used a single or a double X-Y Platform.

If the experimenter's observations and judgments are correct, and if we note the total times spent by subjects A and B in reading and copying in experiments 6 through 11 (see Table 2), we may conclude that these subjects must have exerted a much greater effort when actually reading and writing during experiments 6, 7, and 8 than when carrying out these operations during experiments 9, 10, and 11. The subjects were not asked to make that additional effort, and a review of our instructions to them and their conscious interpretation of these instructions, does not indicate that they or we should have anticipated that the additional effort would be exerted. In any case, we conjecture that the additional effort put into actually reading and writing may be at least partly responsible for the greater discomfort, frustration, and anxiety experienced by subjects A and B during experiments 6, 7, and 8.

The data in Tables 2 and 3, though gathered carefully, are still rather limited. For example, the experiments involved the performance of only four subjects, three of whom (subjects B, C, and D) have had much less experience with the double X-Y Platform than the fourth subject.

Some additional observations made by the experimenter in the course of and subsequent to carrying out the experiments described in this section are given in App. C.

## Appendix A

## INSTRUCTIONS ON HOW TO USE THE DOUBLE X-Y PLATFORM

The following set of instructions is intended to help the user learn to read and to take notes on or copy what has been read using a closed circuit TV system equipped with a double X-Y Platform. The instructions should be carried out in the order they are listed except when an instruction indicates that two or more different paths are to be followed, depending on where the user is in the cycle of reading and note-taking or copying; in this case, proceed directly to the step that is indicated in the appropriate instruction. For example, if at step 4, (b) prevails, proceed directly to step 8, and if (c) prevails, proceed directly to step 9.[1] (See Figs. 5 and 6.)

1. Place the reading material on one working surface and align it within the margins of that surface.
2. Place the writing paper on the other working surface and align it within the margins of that surface.
3. Maneuver the working surface (hereafter referred to as the reading platform) that supports the reading material with either or both hands until you see the area where you are to begin reading at a place that is convenient on the monitor screen. This is usually somewhere on a vertical line near the left edge of the screen.
4. Pull the reading or writing platforms to the left at a rate compatible with your reading speed until (a) you have read the line (in this case, go to step 5); (b) you have read the line *and* completed the page (in this case, go to step 8); (c) you decide to take notes on or copy what you have read (in this case, go to step 9); or (d) you have completed the cycle of reading and writing.
5. Push the reading platform toward the rear of the supporting desk or table until the next line to be read appears on the monitor screen in the location previously occupied by the line just completed.
6. Push the entire platform to the right until the image of the left margin of the line to be read is conveniently located on the monitor screen.
7. Return to step 4.
8. Turn to the next page, align it with respect to the margins of the reading platform, and return to step 3.
9. Pull the reading or writing platform to the left until you see the image of the left margin of the writing paper near the left boundary of the monitor screen. Maneuver the working surface (hereafter referred to as the writing platform) that supports the writing paper until the image of the line and place where you are to begin writing is conveniently located on the monitor screen.
10. While you are writing, pull the writing platform toward the left with your nonwriting hand at a rate that causes the image of the tip of the writing instrument to remain within a small conveniently located area of the monitor screen.[2]

[1] Throughout every step of the procedure about to be described, the user must take care not to move the reading or writing materials on their respective platforms unless he is turning or otherwise exchanging a page and/or aligning these materials with the margins of the platform.

[2] A right- (left-)handed user will hold the writing paper with his left (right) hand and will write with his right (left) hand.

Continue this procedure until (a) you have reached the end of the line (in this case, go to step 11); (b) you have reached the end of the line *and* the end of the page (in this case, go to step 14); (c) you decide to return to reading (in this case, go to step 17); or (d) you have completed the cycle of reading and writing.

11. Push the writing platform toward the rear of the supporting desk or table until the next line to be written on appears on the monitor screen in the location previously occupied by the line just completed.
12. Push either the reading or writing platforms to the right until the image of the left margin of the writing paper is conveniently located on the monitor screen.
13. Return to step 10.
14. Put a clean piece of paper on the writing platform[3] and align it with the margins of the platform.
15. Pull either the reading or writing platform to the left or push it to the right, whichever is appropriate, until you see the image of the left margin of the writing paper near the left boundary of the monitor screen. Maneuver the writing platform until the image of the line and place where you are to begin writing is at a convenient place on the monitor screen.
16. Return to step 10.
17. Push either the reading or the writing platform to the right until the image of the line you read last reappears on the monitor screen at the *same* height that it occupied when you decided to take notes on, or copy from, what you had read, and until the place where you stopped reading is conveniently located horizontally on the screen. *Note that this can be done if you have not moved the reading material on the reading platform and if you have not moved that platform in the y-direction since last leaving the reading material (to take notes on or copy from what you had read).*
18. Pull either the reading or the writing platform to the left at a rate compatible with your reading speed and read until (a) you have read the line (in this case, go to step 19); (b) you have read the line *and* completed the page (in this case, go to step 22); (c) you decide to again take notes on or copy what you have read (in this case, go to step 25); or (d) you have completed the cycle of reading and writing.
19. Push the reading platform toward the rear of the supporting desk or table until the next line to be read is at the height on the monitor screen previously occupied by the line just completed.
20. Push the reading or the writing platform to the right until the image of the left margin of the line to be read is conveniently located on the monitor screen.
21. Return to step 18.
22. Turn to the next page and align it with the margins of the reading platform.
23. Maneuver the reading platform until the area where you are to begin reading appears in a convenient section of the monitor screen.
24. Return to step 18.
25. Pull the reading or the writing platform to the left until the image of the line you last wrote reappears on the monitor screen at the same height on that screen that it occupied when you decided to return to reading, and until the place where you stopped writing is conveniently located on the screen. *This can be done if you have not moved the writing paper on the writing platform and if you have not moved that platform in the y-direction since you last stopped writing.*

[3] The phrase "put a clean piece of paper on the writing platform" is to be interpreted broadly. For example, it not only includes the situation where one piece of paper is removed from the platform and another put down in its place, but also removing or folding under the topmost of two or more pages.

26. While writing, pull the reading or the writing platform toward the left with your nonwriting hand at a rate that causes the image of the tip of the writing instrument to remain within a small conveniently located area of the monitor screen. Continue this procedure until (a) you have reached the end of the line (in this case, go to step 27); (b) you have reached the end of the line *and* the end of the page (in this case, go to step 30); (c) you decide to return to reading (in this case, go to step 17); or (d) you have completed the cycle of reading and writing.
27. Push the writing platform toward the rear of the supporting desk or table until the next line to be written on is at the height on the monitor screen previously occupied by the line of writing just completed.
28. Push either the reading or the writing platform to the right until the image of the left margin of the writing paper is conveniently located on the monitor screen.
29. Return to step 26.
30. Put a clean piece of paper on the writing platform and align it with respect to the margins of the platform.
31. Pull the reading platform to the left or push it to the right, whichever is appropriate, until you see the image of the left margin of the writing paper near the left boundary of the monitor screen. Maneuver the writing platform until the image of the line and place where you are to begin writing is at a convenient location on the monitor screen.
32. Return to step 26.

It should be noted that step 1 and steps 3 through 8 describe how the double X-Y Platform can be used to read printed or handwritten material when the user does not need to take notes on or copy from the material. In that case, 4(c) can be regarded as an alternative that is not under consideration, and 4(d) should be modified to read "you have completed the cycle of reading." Similarly, step 2 and steps 10 through 16 describe how the double X-Y Platform can be used for writing with a pen or pencil when the user does not need to refer to reading materials. Here case 10(c) can be viewed as an alternative that is not to be considered, and 10(d) should be modified to read "you have completed the cycle of writing." Also in this case the sequence of steps to be followed starts with 2 and then proceeds directly to 15.

## Appendix B

# DESCRIPTION OF THE CONSTRUCTION OF THE DOUBLE X-Y PLATFORM

The overall dimensions of the double X-Y Platform when it is in its fully closed position are 24 by 14 by 1.5 in. (see Fig. 7). However, its reading and writing platforms are designed to move in the y-direction 6 in. to either side of the fully closed position, and its carriage frame is designed to move in the x-direction 10.25 in. to either side of the same position. This being the case, the double X-Y Platform requires a rectangular area 44.5 by 26 in. completely free of obstacles to be able to maneuver freely.

With the exception of the capping bars, screws, ball-bearing rollers, and rubber stop blocks, all the parts referred to in the following detailed description of the platform can be assumed to be made of aluminum unless otherwise specified.

The double X-Y Platform consists primarily of four major components:

1. A base structure.
2. A carriage frame.
3. A reading platform.
4. A writing platform.

The main elements of the base structure are

a. A rectangular base plate (24 by 12.5 by 0.25 in.).
b. Two guide bars (24 by 0.50 by 0.25 in.).
c. Ten ball-bearing rollers.

One of the 24 by 0.50 in. faces of each of the guide bars rests against the under face of the base plate. Each of the guide bars is screwed to the under face of the base plate so that it has (1) one of its 24 by 0.50 in. faces in contact with this plate, (2) one of its 24 by 0.25 in. faces in the same plane as a 24 by 0.25 in. edge of the plate, and (3) each of its ends in the same plane as a 12.5 by 0.25 in. edge of the plate (see Fig. 8). Neither the base plate nor the guide bars are in direct contact with the table or desk that supports the double X-Y Platform. Contact with such a supporting surface is provided by 12 circular rubber feet, 0.50 in. in diameter. These are screwed to the under face of the base plate and are arranged in two rows of six near the front and back edges of that plate (see Fig. 9). When resting on the rubber feet, the lower face of each bar is 0.125 in. above the supporting desk or table.

Five ball-bearing rollers are mounted on each of the base structure's 24 by 0.25 in. edges by shoulder screws (see Figs. 8 and 10). These rollers support the carriage frame in its x- or right-to-left and left-to-right motions. At no position in its travel is the carriage frame supported by less than two pairs of rollers.

A 21 by 0.625 in. rectangular slot is cut in the base plate. Its center coincides with that of the base plate and its edges are parallel to those of the base plate. A circular rubber stop block is screwed to the under face of the crossbar of the larger of the two rectangular frames, which make up part of the carriage assembly, at the center of the carriage assembly. The stop block runs in the slot that is centered in the long dimension of the base plate (see Fig. 9). Tne carriage frame can travel 10.25

in. left or right of the position in which the double X-Y Platform is closed with respect to its greatest dimension.

The carriage frame assembly consists primarily of

a. A rectangular frame (the large frame) (13 by 14 by 0.5 in.).
b. A rectangular frame (the small frame) (8 by 14 by 0.5 in.).
c. Two channel bars (24 by 0.375 by 0.375 in.).
d. Two Delrin capping bars (24 by 0.75 by 0.125 in.).
e. Twenty ball-bearing rollers.

Each channel bar is screwed to the under face of both rectangular frames in the direction of the latter's middle dimensions (in magnitude) such that (1) a 24 by 0.375 in. face of the channel bar lies in the same plane as a 13 by 0.5 in. face of the larger rectangular frame and an 8 by 0.5 in. face of the smaller rectangular frame, and (2) a 14 by 0.50 in. face of each rectangular frame lies in the same plane as the end of each of the two channel bars. A capping bar is screwed to the under face of each channel bar such that (1) one of the 24 by 0.125 in. faces of the capping bar lies in the same plane as the outer 24 by 0.375 in. face of the channel bar to which it is affixed and (2) the ends of each capping bar lie in the same plane as the ends of the channel bar to which it is attached. The c-shaped channels formed in this manner enclose the ball-bearing rollers attached to the base structure and are supported by them (see Figs. 10 and 11). The inner 24 by 0.125 in. face of each Delrin capping bar rides lightly against an outer edge of one of the base structure's guide bars to prevent the carriage frame from moving toward or away from the user. Delrin was found necessary since any metal on metal contact ultimately resulted in galling and rough operation.

Five ball-bearing rollers are screwed to each of the four 14 by 0.50 in. faces of the two rectangular frames. Those that are attached to the larger frame support the reading platform in its motion toward or away from the user, and those that are attached to the smaller frame support the writing platform in its motion toward or away from the user (see Figs. 10 and 11). At no position in their paths of travel are either the reading platform or the writing platform resting on less than two pairs of ball-bearing rollers.

Rectangular slots are cut in the center of the front and back top edges of both rectangular frames to permit clear passage of the rectangular rubber stop blocks that are screwed to the under face of both the reading and writing platforms (see, for example, Figs. 11 and 12). These stop blocks, together with the rectangular crossbar of each rectangular frame, limit the y- or line-to-line motion of the reading platform or the writing platform to a 6 in. run either side of the position in which these platforms are closed with respect to the carriage frame.

A braking or friction-generating mechanism has been built into both the large and small rectangular frames. It consists of a spring-loaded friction button inset into the top of the center crossbar of each frame. One of these buttons presses against the bottom face of the reading platform and the other against the bottom face of the writing platform to provide some additional resistance to the y-motion of each of these platforms, and hence makes it easier to move these platforms in the x-direction without having to fear that they will inadvertently also move simultaneously in the y-direction. These friction mechanisms differ markedly from that used in our single X-Y Platform: Perhaps most important is the fact that the frictional loading applied to the double X-Y Platform's reading and writing surfaces can only be changed by disassembling the platform, whereas the friction applied to the working surface of the single X-Y Platform can be varied by simply turning a conveniently located

thumb screw. (See Ref. 2.) It is quite likely that a simple redesign may be possible that would decrease the complexity that is currently involved in changing y-direction friction in the double X-Y Platform.

The overall dimensions of the reading platform are 14.5 by 14 by 0.75 in. and it consists primarily of

a. A reading surface (14.5 by 14 by 0.25 in.).
b. Two channel bars (14 by 0.375 by 0.375 in.).
c. Two capping bars (14 by 0.75 by 0.125 in.).

The channel bars are screwed to the under face of the reading surface such that (1) one of their 14 by 0.375 in. faces is pressed against that surface, (2) another 14 by 0.375 in. face lies in the same plane as a 14 by 0.25 in. edge of the reading surface, and (3) the ends of each channel bar lie in planes common to the 14.5 by 0.25 in. edge of the reading surface. Each capping bar is screwed to the under face of a channel bar such that (1) one of its 14 by 0.75 in. faces is pressed against this bar, (2) one of its 14 by 0.125 in. edges lies in the same plane as the 14 by 0.375 in. outer face of the channel bar to which it is attached, and (3) each of its ends lies in a plane common to an end of its channel bar. The c-shaped channels formed in this manner enclose the ball-bearing rollers attached to the larger of the rectangular frames and are supported by them (see Fig. 11). The inner 14 by 0.125 in. faces of the capping bars ride lightly against the edge of the frame to prevent the reading surface from moving in the x-direction relative to the carriage frame. Further, when the reading surface moves toward or away from the user, it is the under face of this surface and the upper faces of the capping bars that make contact with the rollers.

As pointed out earlier, two rectangular stop blocks are screwed to the under face of the reading surface. They are located on the center line that bisects the face in the y-direction, and are placed so that one of them runs into the crossbar of the large rectangular frame when the reading surface moves in the y-direction 6 in. to one side of its central position and the other runs into that crossbar when the reading surface moves 6 in. to the other side of its central position. Each of these stop blocks consists of a small rubber pad covered by a slightly smaller brass reinforcing plate. This configuration makes it easy to screw the stop blocks to the reading surface, provides cushioning when the stop blocks run into the crossbar, and eliminates the loud harsh noise that would be heard if the stop blocks were made of metal and were to run into the metal crossbar.

The overall dimensions of the writing platform are 14 by 9.5 by 0.75 in. and it consists primarily of

a. A writing surface (14 by 9.5 by 0.25 in.).
b. Two channel bars (14 by 0.375 by 0.375 in.).
c. Two capping bars (14 by 0.75 by 0.125 in.).

The description of the writing platform is exactly the same as that of the reading platform if one substitutes the terms "writing" for "reading," "9.5 in." for "14.5 in.," "smaller" for "larger," and "small" for "large" in the above description.

The upper faces of the reading and writing platforms are painted light brown. A silver rectangular border is painted on each of these faces. The one on the reading platform encompasses an area 12 by 14 in. Both of these rectangular areas are centered and aligned with the edges of their respective platforms. Silver lines that bisect the rectangular areas horizontally and vertically are also painted on these surfaces. A small silver circle, whose center coincides with the geometric center of the upper face of the double X-Y Platform when it is fully closed, is painted at the

appropriate place on the reading platform, and a short vertical silver line was also drawn through the center of the circle (see Fig. 7).

The brown and silver used to paint the upper faces of the reading and writing platforms were chosen because their gray values can be distinguished by a black and white TV camera from those of most paper used in printed, typed, and handwritten material. These colors are not, however, so different from those gray values as to cause appreciable degradation in TV image quality when the brown or silver of a platform face shares a TV monitor screen with the whites or off-whites of most reading and writing materials, or when the composite image is viewed using contrast reversal.

The markings described above and shown in Fig. 7 were meant to assist the user in centering and orienting the double X-Y Platform below a TV camera and in orienting reading and writing materials with respect to the boundaries of the platforms on which they rest.

From what has been said in this appendix and from Fig. 7, we see that when closed the double X-Y Platform is symmetric with respect to its longest dimension. Therefore, it does not matter whether the writing platform is located to the right or to the left of the geometric center of the closed double X-Y Platform. Hence the double X-Y Platform can be used with equal comfort by both right- and left-handed users.

In addition, it should be noted that there is no reason why the reading platform cannot be used for writing and the writing platform for reading. In designing the double X-Y Platform, we made the working surface to be used for reading a little larger (14.5 by 14 in.) than the one to be used for writing (9.5 by 14 in.), because, at that time, we felt that the user might need more space in the x-direction for reading than he would need for writing. Even if this conjecture is correct, it in no way negates the reasonableness of using either working surface for reading or for writing.

## Appendix C

## EXPERIMENTER OBSERVATIONS AND COMMENTS

The following are some additional but important observations made by the experimenter in the course of and subsequent to carrying out the experiment described in the last section of this report:

1. In experiments 6, 7, and 8 with the single X-Y Platform, subject A placed his writing pad under the reading material. When writing on the upper two-thirds of a page, he permitted the writing pad to protrude beyond the top of the reading material, and when writing on the lower third of a page, he permitted it to protrude beyond the bottom of the reading material. Subject B chose a different technique. While he read, his writing pad was placed to the side and off of the X-Y Platform, and when he wanted to write, he placed that pad over the reading material. He then wrote and maneuvered the pad, so as not to move the reading material or the X-Y Platform. He found that he could easily locate where he had left off reading after completing a period of writing. However, this technique caused him to maneuver the X-Y Platform only when reading, and hence he was obliged to maneuver the writing pad rather than the X-Y Platform when writing.

2. In all experiments involving writing, subject A used the entire width of the writing pad, as did subject B—except in experiment 10. In the latter experiment, each subject was required to copy from a text that when opened was 16.375 in. wide and 9.25 in. deep. Since the reading platform of the double X-Y Platform is 14.5 in. wide and 14 in. deep, this meant that when copying from a left-hand page of the text, the subject was faced with the problem of the reading material intruding about two inches on the left of the writing platform. Subject B let the text overlap his writing pad and only wrote on that portion of the pad not covered by the text. Thus he used only a limited portion of the width of his writing pad when copying from a left-hand page of the text but the full width when copying from a right-hand page. As pointed out above, subject A used the full width of his writing pad when copying from a left- as well as a right-hand page. In the case of a left-hand page, he used his left hand to raise the right-hand edge of the text when he had to write near the left margin of the writing pad and when he was obliged to move either the reading or the writing platform in the y-direction.

3. In experiments 10 and 11, both subjects A and B handled, in the same way, the problem of viewing alternately at moderate to high magnifications (1) pages of text more than an inch above the reading platform and (2) the upper page of a pad, which is at most 1/4 in. above the surface of the writing platform. They adjusted the focus ring on the zoom lens so that the reading material was in sharp focus, and throughout the entire process of copying from one side of the page, they made no change in lens focus. This meant that the image of a subject's handwriting was not in sharpest focus, but it did not appear to cause either subjects A or B any difficulty. This can be explained in part by the fact that both subjects normally see most objects out of focus, except when using special visual aids, and in part because they have adjusted well to coping and living with defocused information. Also, their handwriting, as well as that of most other people, tends to be larger than ordinary printed material, and hence can be read with comparative ease even when the optical system is somewhat out of focus.

There is an easy way to solve the problem of keeping two pieces of material in

sharp focus at moderate or high magnification, when the upper page of one piece of material is much higher above the supporting X-Y Platform than the other. Place below the thinner material a book or other suitable object that has the thickness and lateral area needed both to raise the upper face of the thinner material to the same level as that of the upper face of the thicker material and to provide the thinner material with support throughout most or all of its lateral area.

4. The reading and writing platform of the single X-Y Platform used in experiments 4 through 8 was 12 in. wide and 14 in. deep and moved on drawer slides 4.375 in. in the x-direction to either side of its closed position and 5.875 in. in the y-direction to either side of that position. Comment 1 above leads us to speculate as to what would have happened if we had used a larger single X-Y Platform, for example, a platform (1) that was wide enough to have accommodated, side by side, *Concepts in Science* (fully opened) and a pad of 8.5 by 11 in. writing paper, (2) that moved far enough in the x-direction on either side of its closed position to permit the user to view on his monitor every portion of the entire width of the open book and writing pad, and (3) that moved far enough in the y-direction on either side of its closed position to permit the user to view on his monitor every line on a page of the book or on a page of the writing pad. Such a platform would permit the user to read and copy what he read without moving the book over the pad, or the pad over the book, or without removing one or the other of these items from the platform. However, the platform would *not* "remember" the line on which reading or writing had last stopped, and hence the user would be required to constantly shift the reading or writing material in the y-direction to compensate for this shortcoming; otherwise, he would have to resign himself to hunting for the line where he left off reading (writing) when he stopped writing (reading) and wanted to return to reading (writing). Even recognizing this drawback of an enlarged single X-Y Platform compared with a double X-Y Platform, we can't help but wonder whether such a single X-Y Platform would have proved easier to use for copying than the small single X-Y Platform we used in experiments 4 through 8.

5. From comment 2 above, we speculate as to whether we would have been wiser to have made the reading platform of the double X-Y Platform a few inches wider. If this had been done, the problem of reading and writing material overlap, which occurred when reading and copying from a left-hand page of *Concepts in Science* would have been avoided. However, a wider reading platform would have required a larger desk or table top area cleared of obstacles for the operation of the double X-Y Platform. Further, adding inches to the width of the reading platform would not guarantee that sooner or later a user would not need or wish to read a volume that when opened spanned a distance that exceeded the width of the enlarged reading platform.

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